
Addressing Light Pollution in Your Community

Regulations for Towns and Small Cities

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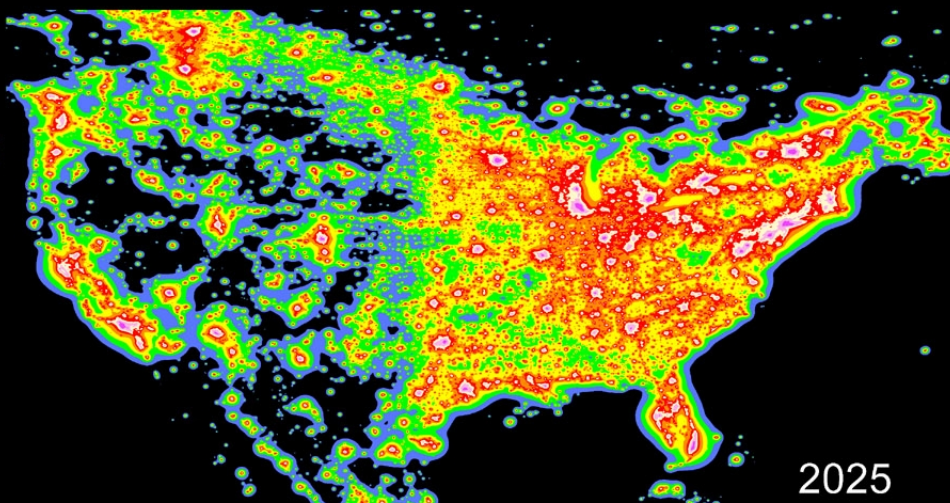
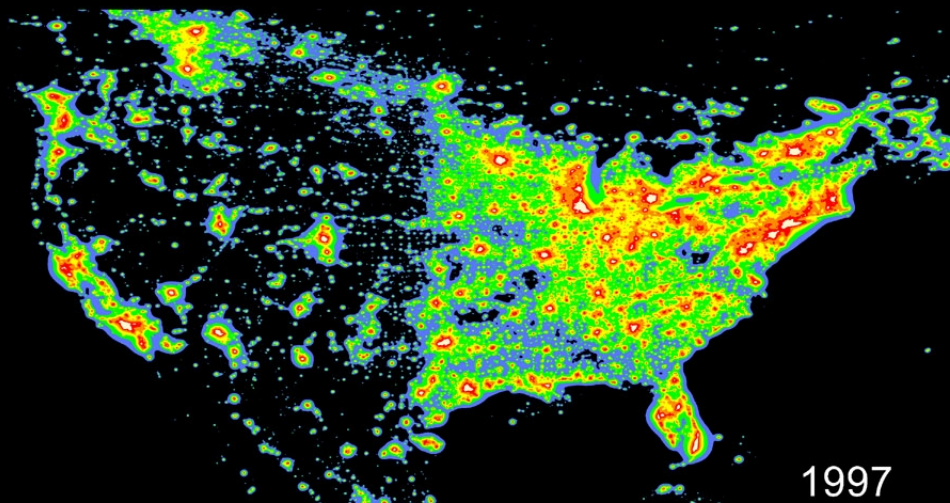
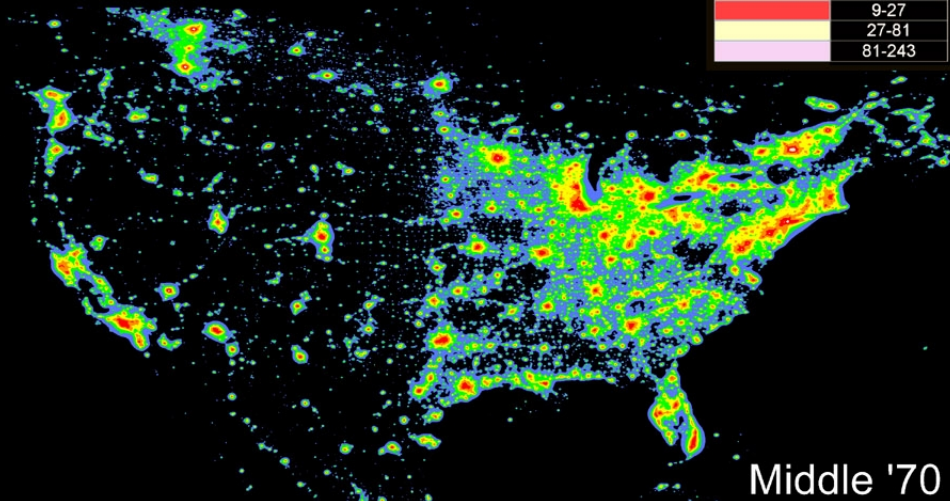
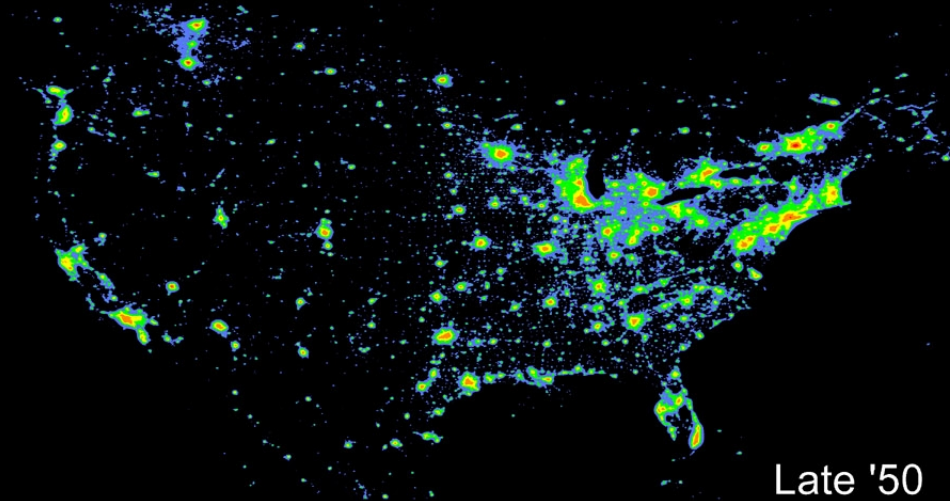
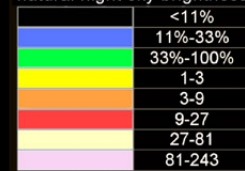
Why Regulate Outdoor Lighting?

- **Light doesn't stop at property boundaries**
 - Control objectionable light on other's & public properties
- **New attitudes**
 - Old- "close your shades"
 - New- want greater control on what happens to my property
 - Growth in lighting is being noticed by everyone
- **Outdoor lighting growing 5-10%/year**
 - Population growth, density
 - Affluence leads to commercial growth

Artificial Night Sky Brightness due to Light Pollution in North America

A preliminary picture of the growth from 1950 to 2025

Artificial night sky brightness at zenith, at sea level, for standard clean atmosphere as fraction of the average natural night sky brightness



Outdoor Lighting

- **Basics of outdoor lighting are very simple**
 - We intuitively sense “good” vs. “bad” lighting
- **Details can be somewhat complex**
 - Keep requirements as simple as possible while still realistic
 - Use objective criteria in regulation (no judgment)
- **This talk**
 - Shows + and – arguments for an issue
 - Hopes to provide understanding on how to customize an ODL regulation to your own needs

Detrimental effects of outdoor lighting

- **Glare –**
 - Direct view of light source against dark background
 - Annoyance, vision disturbance, and can be a safety hazard
 - Cause: light aimed horizontally, not down
 - “The sensation of visual discomfort or loss in visual performance and visibility produced by luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted.”
- **Light Trespass –**
 - Unwelcome light spilling off originating property
 - Cause: light aimed horizontally, not down , too much light power used
 - “DIRECT or INDIRECT LIGHT produced by an artificial light source and which shines outside the boundaries of the LOT containing the LUMINAIRE.”
- **Sky Glow –**
 - “Upwardly directed artificial light that is scattered back toward the ground by particles in the atmosphere. “
 - Excessive sky glow can almost completely block out views of stars.
 - Cause: upward-directed light and too much light power used.

Glare interferes with good vision

Unshielded lighting-veiling illuminance



It's hard to see in the presence of glare caused by unshielded lighting.

Can you see the pedestrians walking in front of your car?

Shielded lighting



With shielded lighting the glare is reduced significantly.

Safety is improved.

Glare examples in NW Boston area



Car dealer lot with bright floodlight.....



shining onto road



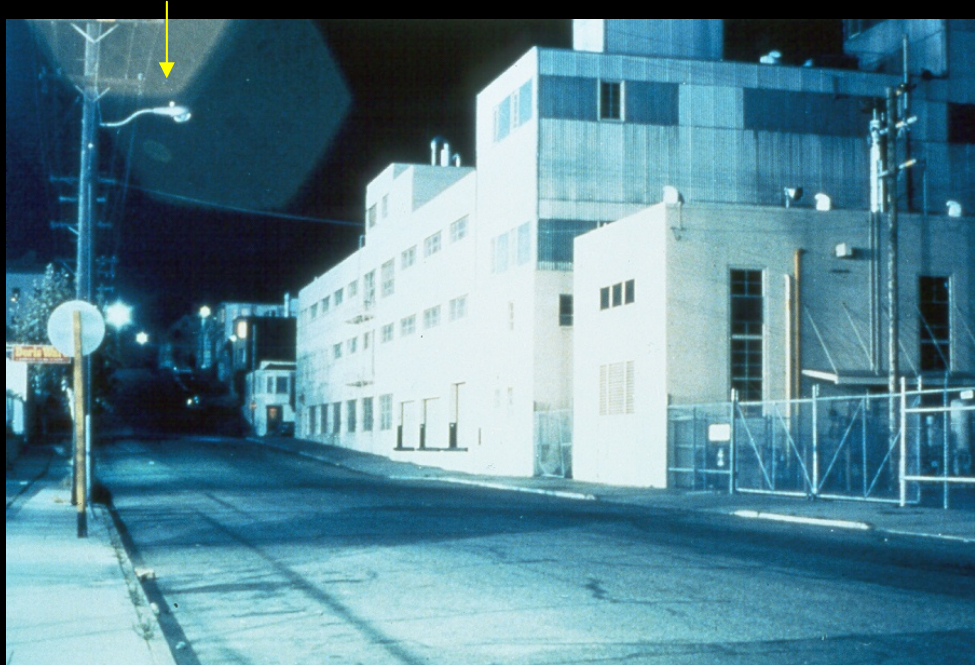
Parking lot glare visible through trees

Light Trespass Example

Floodlight mounted here...

Shining onto building
across street... →

Streetlight with light detector
switch is forever off!



Reduced Visibility of Stars in Sky-glow

Near Ottawa, Ontario



During Blackout 1998



Normal Night

Fundamentals to control detrimental effects

- **Use only FULLY SHIELDED fixtures**
 - All light projected above a horizontal plane passing through the lowest direct-light-emitting part of the LUMINAIRE
 - Equivalent to IESNA “Full Cutoff” or “FCO” designation
 - Applies to all lamps above a specified power (Table 1)
 - **ADDITIONAL SHIELDING** for lights near ($< 3 \times$ pole height) to property boundary
- **Use Correct lighting levels**
 - Good lighting uniformity more important than lighting level
 - Guidelines by Illuminating Engineering Society of NA (IESNA)
- **Use lighting only during hours of operation**
 - “Turn off lights after leave the room”
- **All three of these address all the detrimental effects of lighting**
- **ENFORCEMENT**
 - Fair and objective regulations
 - Plan for effective and simple enforcement- and then do it!

Unshielded light examples



Pole-mounted 400-W floods



Drop-lens 100-W mercury road light



Light pattern from floods

Unshielded lights---

- **Poor control over light direction**
- **Light spill and glare unavoidable**

Examples of fully shielded lights



Fully shielded road light



Light pattern from FS parking lot lights

Fully shielded lights

- No light emitted above horizontal plane thru lowest light-emitting part
- Provide good lighting with reduced glare, light trespass and sky glow
- Recognize by their flat, horizontal, clear lens

Enforcement

- **Why needed?**
 - Outdoor lighting often not well thought out; people tend to DIY
 - Seek “LC Certified” lighting designers
 - Currently no industry sanctioned limit on maximum levels
 - Quality of “lighting designers” varies widely
- **Enforcement inspection goals**
 - Objective- no qualitative judgment needed by inspectors
 - Simple- inspectors are regular staff with minimal training
 - Inspections carried out
 - From the ground- no ladders or buckets
 - In daytime, not nighttime

These enforcement Goals lead to a....

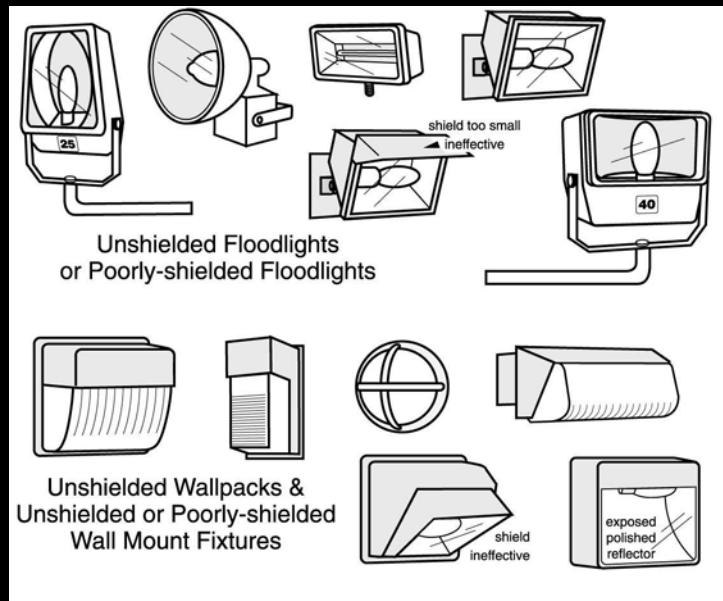
>> **HARDWARE** driven, not **PERFORMANCE** driven regulation

Hardware-oriented enforcement

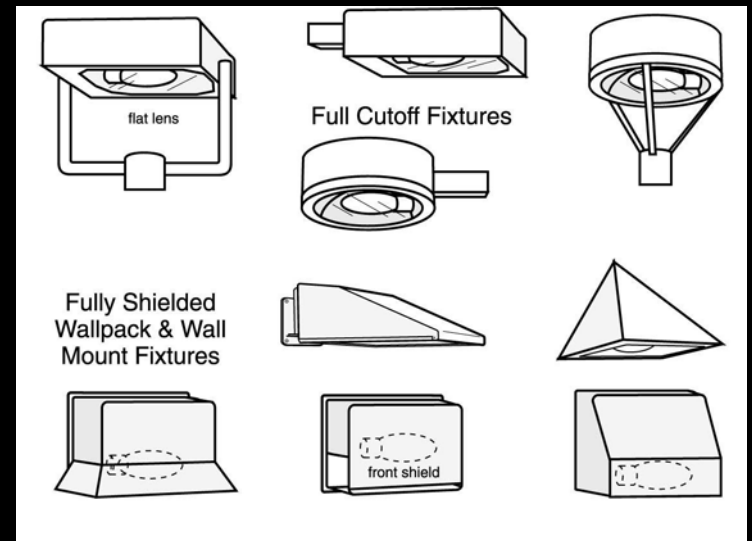
- **Fully Shielded**
 - Construction of hardware >> visual recognition as fully shielded.
 - Don't need to know model number, photometric details, etc
 - No night time measurements using photometers
- **Lighting levels**
 - Use Lighting Plan submitted BEFORE construction
 - Plan signed off by responsible designer
 - Spot checks in day time can ensure compliance
 - Inspect luminaires on the ground before installation
 - Can judge lamp size from ground on installed light in day time
- **Hours of Operation**
 - Realistically, enforcement by occasional observation or complaint.

NOT Fully Shielded vs. Fully Shielded

Prohibited
under current Acton bylaw



Allowed
under current Acton bylaw



Fully Shielded- Special Provisions

(sample considerations)

- **Externally illuminated signs**
 - Lighting for signs realistically can't be “fully shielded”
 - Projected downward from above...
 - SHIELDED and shall be focused directly at the SIGN..
 - LAMP not visible from STREETS, or Residential or Public LOTS
- **UP-LIGHTING**
 - Minimize “decoration” lighting
 - United States Flag, Public monuments, Selected Building facades.
 - Fixtures to FOCUS LIGHT ON TARGET, no wide-angle fixtures
 - LAMP not visible from STREET or Residential or Public LOT
 - Building façade illumination
 - Public buildings only? NO façade lighting allowed?
 - < 0.05 watts LAMP power per square foot façade surface.
 - Lighting Plan shall specifically demonstrate compliance

Fully Shielded- Special Provisions (Illuminated Outdoor Recreation Facilities)



Not well shielded



**Much better shielded
(but NOT “fully shielded”)**

How to ensure use of “better shielded” design?

Fully Shielded- Special Provisions

(sample considerations)

- **Illuminated Outdoor Recreation Facilities**
 - These are tough to write a regulation for.
 - Most available Sports Lighting is NOT FULLY SHIELDED
 - Must define SHIELDING and LIGHT TRESPASS requirements
 - Allow use of high light poles (any town restriction?)
 - Beam of light no higher than about 60 degrees (depressed 30 deg)
 - Regulate LIGHT TRESPASS onto STREETS, abutting LOTS
 - less than 0.5 foot candles.
 - This is key to sports lighting regulation.
 - LIGHTING PLAN demonstrates LIGHT TRESPASS satisfied.
 - LAMP not be visible from a STREET, or an abutting LOT
 - Alternatively, installer retain a qualified independent lighting consultant
 - measure the maximum luminance from STREETS, or abutting LOTS
 - Less than 2500 cd/sq.m.

Fully Shielded- Special Provisions

(sample considerations)

- **LUMINAIRES in a Local Historic Districts – (sample)**
 - Talk with your local Historic District Commission
 - LUMINAIRES exempted from fully shielded(?)
 - IESNA “CUTOFF” or “U1”
 - Externally illuminated signs in Local Historic District may use UP-LIGHT
 - SHIELDED LUMINAIRES
 - LAMP not be visible from a STREET, or from an abutting LOT

Whom is your regulation directed at?

- **Commercial?**
 - Permitting process probably already exists(?)
 - Enforcement lever = **occupancy permit**
 - Don't depend on **legal action** to enforce
 - Sunset provision vs. grandfathered (the big question....)
- **Town government and schools?**
 - Normally these categories are exempt from local regulations
 - Ask town and school administrations for **voluntary compliance**
 - Get specific understanding from Town officials
 - “Going in” position of projects = compliance (with exception reserved)
- **Residential?**
 - Community opinion - majority of residents approve of regulation?
 - Original occupancy permit probably not effective for enforcement
 - Many homeowners “do it themselves”- no permit pulled
 - Enforcement by complaint only(other methods?)
- **Utility Pole Rental Lighting?**
 - Hard problem. Lighting company doesn't need a permit to install lights

Uses of outdoor lighting

(Prepare for discussion of lighting levels)

- **Safety**
 - Safety is freedom from DANGER
 - Proper footing while walking, seeing pedestrians
 - Sports events
- **Security**
 - Security is freedom from WORRY
 - Crime, vandalism, “protection of persons and property”
- **Business**
 - Illumination of outdoor sales areas
 - Attract customers to the store
 - Sign illumination
- **Decoration**
 - Illumination of building facades, bridge structures, monuments, etc

Light levels

- **How Much Light is Enough?**
- **Many installations use much higher light levels than...**
 - Needed for good vision
 - IESNA-recommended minimums
 - Uniformity more important than level of light for good vision
- **Some reasons for higher-than-needed light levels**
 - Don't know what's needed (didn't hire professional help)
 - **Security** Wrong notion-"the more the better"
 - Common Belief: "brighter lights = better security"
 - Contrast safety vs. security needs
 - **Sales** Common Belief: "bright lighting sells"

Security Lighting:

Is bright lighting effective in reducing crime?

- **Recent survey of inmates convicted of property crimes**
 - **Question: what were deterrents to you carrying out crime?**

- **Results:**

Top deterrents were;	(percentage of respondents)
-----------------------------	------------------------------------

- | | |
|------------------------------|--------------------------------|
| – Dog | 15.8% |
| – Alarm System | 15.1% |
| – Move to safer area | 10.2% |
| – Someone at home | 9.7% |
| – Owner buy/use a gun | 7.3% |
| – Security lighting | not important to crooks |

Security Lighting:

Is bright lighting effective in reducing crime?

- **Studies of effectiveness of lighting on reducing crime**
 - “Sometimes makes an improvement, sometimes doesn’t matter, sometimes makes situation worse” –(NIJ report to Congress *PREVENTING CRIME: WHAT WORKS, WHAT DOESN'T, WHAT'S PROMISING [1995]*) <http://www.ncjrs.gov/works/>
 - Improvement in roadway lighting reduces crime [2000]
 - BUT daytime crime reduced too -other factors involved?
 - Dark campus experiments
 - Turning off lights actually reduced vandalism.
- **Survey studies show: (Clanton et. al. [2002], private comm.)**
 - More glare leads to feeling of less security
 - Poor or no correlation between lighting levels, feeling secure

Does this parking lot make you feel secure?



Walking toward your car against strong glare.....feel secure?

Does this parking lot make you feel secure?



More uniform lighting reveals a person hidden by glare, non-uniformity!
Enhance security by eliminating glare and improving uniformity

Light levels

- **How Much Light is Enough?**
 - **Sales Common Belief: “bright lighting sells”**
 - Bright lights do get attention (but may offend)
 - RPI study; uniformity is the key
 - Light for the task, e.g. Outdoor sales areas, need somewhat brighter lights

“Bright lighting sells” ?

Customer reaction to improved lighting

Original fixtures



Full cutoff fixtures



“The percentage of drivers turning in to the station and the mean number of gallons of gasoline sold daily increased immediately following the change of lighting from the drop-lens, non-cutoff luminaires to the flat-lens, full-cutoff luminaires”

An Evaluation of Three Types of Gas Station Canopy Lighting

P.R. Boyce, C.M. Hunter, and S.L. Vasconez, Lighting Research Center

Rensselaer Polytechnic Institute

Why use recommended light levels?

- **Prevent light level ratcheting**
 - Protect existing responsible businesses from new adjacent development
- **Save money, energy costs**
 - Typical lot of 20 lights, 4x over IESNA recommendations, => \$7500/10 years in excess electricity cost
- **Visually effective**
 - Uniformity, not total level, more important for good vision.
 - Reduced levels have really been shown to provide good vision
- **Treat customers considerately**
 - Provide safe, adequately lighted area that feels secure
 - More pleasant shopping experience.
 - RPI study of customer preference
 - Attract customers with good lighting and provide better business?
- **Reduce sky glow**

Regulating lighting levels

- **Simple method (but not as accurate)**
 - Use **POWER** of all lamps summed together per unit area
 - + Doesn't require any measurement, only specification on plan, and checking in field (after fixtures delivered and before erection)
 - - Not completely accurate; different lamps emit different lumens/watt; probably good enough until radically different lamps developed (LED?)
- **More accurate method (but more complicated)**
 - Use **LUMENS** of all lamps summed together per **UNIT AREA**
 - + This is exactly what determines Light Levels on the ground
 - - Lumen levels change with age of lamp.
 - - Lumen levels need to be measured at night to verify regulation

Regulating lighting levels-cot'd

- **Make use of required Lighting Plan**
 - Shows position and power of all outdoor lights in plot
 - Designer must calculate power/unit area
 - Demonstrate compliance with regulation
 - Sign document
 - Review before permit issued to assure compliance
- **Exemptions (sample list)**
 - Internally illuminated signs....
 - Temporary holiday lighting....
 - Emergency lighting...
 - Temporary lighting used on construction sites
 - Lighting during special events such as fairs...
 - Warning and alarm lights....

Regulating lighting levels- Allowed Power

- **Allowed Lighting Power; Define ACTIVITY AREAS.**
 - Each Activity Area clearly marked and labeled on the Site Plan.
 - No overlapping Activity Areas.
 - LUMINAIRE must be within 100 feet of an activity area
 - Unlit areas of the LOT may not be used to calculate Allowed Lighting Power.
- **PARKING LOTS, driveways, walkways, bikeways**
 - 0.05 watts per square foot plus 5-foot wide margin
- **BUILDING entrance areas –**
 - 10 watts per linear foot of the width of all doors, plus six feet per door.
- **BUILDING CANOPIES –**
 - 0.4 watts per square foot of the ceiling area of walkway CANOPIES.
- **Retail sales CANOPIES –**
 - 0.6 watts per square foot of ceiling area of service station and retail sales CANOPIES.
- **Retail sales frontage –**
 - 15 watts per linear foot of sales frontage. Frontage measure
- **OUTDOOR SALES AREA –**
 - 0.6 watts/square foot times area OUTDOOR SALES AREA.

Acton Outdoor Lighting Bylaw

sample bylaw at <http://www.town.acton.ma.us/olec/>

- **Previous bylaw- (1984-2004)**
 - Glare and light trespass-Very stringent shielding specifications
 - New Site Plan Special Permit (decreasingly applicable as Town built out)
 - Most of town had fully shielded lighting
- **Current (2004) bylaw:**
 - Glare and light trespass
 - Updated language and practical specifications
 - Exempt small lights
 - Spell out exemptions and special cases
 - More quantitative
 - Light levels and hours of operation
 - Applicability
 - Commercial, municipal, non-profit, residents (By Site Plan Special Permit)
 - Major renovation (>25%) as well as new installation
 - Provision for lights off after business hours
 - Municipal (voluntary)

Lighting Zones

(Not needed for towns and small cities)

- **Five zones from very dark to very bright lighting allowed**
 - New lighting in zone defined by lighting that already exists
 - Model Lighting Ordinance from IDA
- **Advantages/Disadvantages**
 - + Preserve dark regions from additional intrusive lighting
 - + Limits worst obtrusive lighting to specific areas of city
 - - Stakes off bright areas that will probably always be bright
 - - Complicated administration
 - - Doesn't really address Sky Glow
- **Most towns and small size cities probably don't need this**
 - Acton (21,000) bylaw has one zone for all

YOUR outdoor lighting regulation

- **UNDERSTAND lighting basics**
 - Appoint Committee
- **DON'T simply copy someone else's bylaw**
 - Look for what works, is consistent with your town
- **ADDRESS Glare, Light Trespass, Sky Glow**
 - Fully shielded- this alone is a good starter regulation
 - Light levels- include if comfortable
- **ENFORCEMENT**
 - Plan how- Hardware or Performance?
 - Don't rely on Plans only; Use inspections
- **UNDERSTAND your own bylaw**

Resources

- **International Dark Sky Association IDA**
 - <http://www.darksky.org/mc/page.do>
 - Bulletins, reports, slides
 - Model Outdoor Lighting Ordinance
- **New England Light Pollution Advisory Group NELPAG**
 - <http://nelpag.harvee.org/>
 - Regional resources and help
- **Acton Outdoor Lighting Education Committee**
 - <http://www.town.acton.ma.us/olec/>
 - Acton bylaws posted on this web site
 - Acton Outdoor Lighting Bylaws (1984 and 2004)
 - Specific experience with outdoor lighting regulations in MA

Summary

- **Obtrusive lighting**
 - Intrudes on rights of others. Glare, Light Trespass and Sky Glow.
- **Fully shielded light fixtures aimed vertically down at pavement**
 - Addresses Glare, Light Trespass and Sky Glow.
 - Simple, effective enforcement
- **Light levels- how much light to use?**
 - Many installations use much higher light levels than needed
 - Uniformity most important; more is NOT better.
 - Good lighting improves sales
 - Power/unit area => simple, good enough specification
 - Or, use Illuminance specification if expertise, night inspection no problem
 - Require to show in Lighting Plan compliance w/Power/unit area
 - Inspection after luminaire delivery, BEFORE erection to assure power met
 - UNDERSTAND your own bylaw, make sure ENFORCEABLE

Costs of excessive glare

- Loss of resolution and detail in area around bright light
- In extreme cases, vision overload, confusion, error

Friday 31 May 2002: (*Newsquest, Oxfordshire Ltd*)
Technician died after accident

A man was hit by car and killed after a security light temporarily blinded the driver.

"On November 10 last year, Jimmy Smithson, 56, of no fixed address, left The Mounts Bay Inn, in Nuneham Courtenay, and tried to cross the A4074 ... "

- IESNA standard for roadway lighting specifically requires calculation of glare and design for low glare

Glare demonstration

- **Glare: un-obscured view of bright lamp- causes our vision to become less sensitive in the region around the lamp.**
- **When the light is tipped up so you can see glare from the bulb.....**
 - ⇒ Is there any change in the amount of detail you can see of features in the speaker's face?**

-
- Table 1. LUMINAIRES whose LAMP wattage exceeds the values in Column A of this table shall be SHIELDED. LUMINAIRES whose LAMP wattage exceeds the values in Column B of this table shall be FULLY SHIELDED.
 - Lamp type A – SHIELDED B – FULLY SHIELDED
 - Incandescent, Halogen 60 w 120 w
 - High Pressure Sodium,
 - Metal Halide, Mercury
 - Vapor, other HID
 - 35 w 35 w
 - Fluorescent,
 - Low Pressure Sodium
 - 13 w 20 w